

AD 682851

TRANSLATION NO. 343

DATE: 22 June 1951

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Translated from Dok. Akad. Nauk, 64 (1949), 3, 425 - 428.

ON THE CHEMICAL MECHANISM OF IMPULSE
TRANSMISSION IN THE AFFERENT NERVES

«О химическом механизме проведения
возбуждения в афферентных нервах.»

D.Ye.RYVKINA

(Presented by Academician A.I.OPARIN, Nov. 24, 1948)

Many workers deny the existence and the rôle of a cholinergic mechanism (the acetylcholine-cholinesterase system) in the transmission of stimuli in the afferent nerves, and postulate the existence, in the case of these nerves, of some other mechanism [1,2]. However, along with this there are indications of the presence of acetylcholine in the sensory nerves [3-5]. A certain amount of data has also been produced on the release of acetylcholine in the processes of excitation in the afferent nerves, principally in the researches of Soviet scientists: thus V.P.SONIN [6] and M.M.DENISENKO [7] were able to discover the cholinergic mechanism of afferent * post-root hyperemia, the histaminergic character of which was known earlier [8-10]; B.I.KADYKOV, A.V.LEBEDINSKI and N.S.SAVVIN [11] point out that the antidromic effects in the afferent nerves involve a double mechanism: both an acetylcholine and a histamine mechanism.

Also interesting are L.B.PEREL'MAN'S findings on the lowering of the threshold of pain sensation and tactile sensation in patients under the influence of proserine.

Hence there arises the question of a more detailed comparative study of the content of histamine and acetylcholine and of their respective enzymes in the afferent nerves, and such a study was indeed undertaken in a series of works by Kh.S.KOSHTOYANÇ and his associates [13]. Previously thereto, in a comparison of the histamine levels in purely sensory and purely motor nerves, we had already discovered a greater lability of these levels in the posterior cerebral spinal roots and a greater stability of these levels in the anterior roots [14]. In the present communication we are publishing corresponding data on acetylcholine.

* In the text, "efferent". (Tr.)

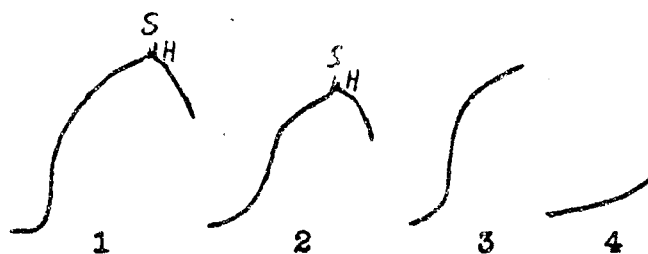


Fig. 1. S, washed with Tyrode's solution
 H, haemolymph of vineyard snail
 1, acetylcholine $0.1 \text{ } \gamma/\text{cm}^3$
 2, extract of posterior roots, cat
 (25-mg sample), Aug. 17, 1947
 3, extract of posterior roots, cat
 (28-mg sample)
 4, the same as in 3, after 20-
 minute preliminary treatment
 with haemolymph of vineyard
 snail, Aug. 29, 1947.

MATERIAL AND METHOD

As in our preceding researches, we used cats and dogs as our test animals. The cats were subjected to general ether anaesthesia. The dogs were given ether, and in some cases ether plus morphine. Certain of the tests were conducted with a preparatory injection of eserine (1 mg/kg). As the roots were removed, they were placed in chilled trichloroacetic acid. Then they were dried with filter paper and weighed on a torsion balance. The trichloroacetic extract was divided into two portions, upon one of which, in the ordinary manner, a histamine determination was made (data given in communication [14]); the other was processed as per CHANG and GADDUM [13]. Recording was carried out upon the usual biological test-object, namely the eserinated rectus abdominis muscle of a frog. For the identification of acetylcholine, the following methods were employed: to the muscle in a test-tube cholinesterase was added (hemolymph of vineyard snail) and the subsequent relaxation was recorded; half of the filtrate was mixed with the haemolymph, placed in a thermostat for 30 minutes and then tested; half of it was subjected to a 40-minute boiling with added alkali. We give the results in Tables 1 and 2 and in Fig.1.

Table 1

Acetylcholine in Posterior and Anterior Roots in Dogs (γ/g)

Test No.	Date 1947	Posterior roots	Anterior roots	Remarks
1	18/2	24	40	
2	21/2	0	0	
3	24/2	12	12	
4	26/2	20	5	
5	3/3	0	15	
6	4/3	0	8	Eserine
7	7/3	9	22	
8	14/3	0	8	
9	17/3	0	8	Morphine
10	18/3	2	7	Eserine
11	20/3	20	-	
12	20/3	0	-	
13	24/3	0	0	
14	24/3	0	8	
15	24/3	16	12	

Test No.	Date 1947	Posterior roots	Anterior roots	Remarks
16	26/5	4	28	
17	27/5	18	0	
18	27/5	0	0	
19	27/5	0	0	
20	30/5	19	7	
21	30/5	13	10	
22	30/5	0	19	
23	6/6	0	1	
24	6/6	7	5	
25	6/6	18	4	
26	13/6	100	54	
27	13/6	54	5	
28	30/6	0	16	
29	30/6	0	0	
30	4/7	0	16	Morphine
31	11/9		-	"
32	11/9	0	0	"
33	23/9	30	0	"
34	23/9	0	130	"
35	23/9	0	60	"
36	26/9	16	8	"
37	30/9	80	95	"
38	30/9	0	8	"
39	30/9	0	0	"
40	1/11	0	4	"

We performed a total of 40 analyses of nerves from dogs and 10 from cats. As will be seen from the tables, there is a content of acetylcholine in both the posterior and the anterior roots, but it is variable in amount. In dogs, (Table 1), acetylcholine was discovered in the posterior roots in 45% of the cases and was not detected in 55% of the cases; in the anterior roots it was present in 78% and not detected in 22%. A preliminary

subcutaneous injection of eserine did not alter the results. In cats (Table 2), the figures obtained are steadier than in dogs. Cats, consequently, are more suitable for experiments of this kind.

Table 2

Acetylcholine in Posterior and Anterior Roots in Cats (γ/g)

Test No.	Date 1947	Posterior roots	Anterior roots	Remarks
1	8/3	6	6	
2	13/8	20	20	
3	13/8	48	0	
4	16/8	24	64	
5	16/8	48	0	
6	29/8	28	64	
7	29/8	8	12	
8	11/9	0	0	
9	20/10	0	16	
10	13/11	2	88	

Thus under conditions of general ether anaesthesia and with the *rectus abdominis* muscle of the frog used for recording, acetylcholine is found both in the posterior and in the anterior roots, but not in 100% of the cases. Like histamine, it is more stable in the posterior roots and more labile in the anterior roots.

In the determination of acetylcholine in the cerebro-spinal roots, the general condition of the animals and their behavior prior to anaesthesia is of great importance. In large, healthy and quiet animals the content may be quite large (Test No. 26), and the figures found will generally be steadier than in small, nervous, weak animals. Under conditions of intense excitement acetylcholine as a rule will not be present either in the posterior or in the anterior roots. Thus the steadiness or unsteadiness of the acetylcholine content in the cerebral spinal roots is determined by internal factors connected with the general condition and constitution of the animal. The same applies to histamine, though in a lesser degree.

T.G.PUTINCEVA of our laboratory repeated the acetylcholine determinations for the posterior and anterior roots of cats. Using the heart muscle of the frog for recording purposes, she detected an acetylcholine effect, antagonized by atropine, in all her analyses. These results are supported by data on the activity of cholinesterase in cat nerves. The cholinesterase activity was determined biologically, from decomposition of acetylcholine. The following results were obtained (mean of five tests): activity, posterior roots, 6 γ /g hr; anterior roots 3 γ /g hr.

The experimental data presented in this paper and the results of the tests which we performed enable us to conclude that there is need to revise the widely held belief in a difference of chemical basis as between motor and sensory nerves, and to reconsider the implied exclusion of the afferent nerves from the cholinergic group. Our experimental findings furthermore bring out the great importance of the question of the mutual relationship of histamine and acetylcholine (and their accompanying enzymes) in the sensory and motor nerves.

Now the uncovering of the chemical bases of the transmission of stimuli in the afferent nerves is a matter closely connected with our understanding of the chemical bases of pain phenomena. In view of this fact, there is very great interest in EMMELIN and FELDBERG's discovery (16) of quite large quantities of acetylcholine and histamine in the hairs of the nettle, which cause a phenomenon closely similar to the pain phenomenon. It has furthermore been found that the simultaneous injection of both the said substances causes a sensation of pain and burning. The connection of both these substances with the phenomenon of pain is also indicated by the fact that many substances which reduce pain will inhibit both the histamine and the acetylcholine effects. It is in this way, according to our findings, that citral and cyohol (Prof. S.D.BALAKHOVSKI's preparations) act. These findings support the thesis of a double chemical mechanism of transmission in the afferent nerves.

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Received Nov. 22, 1948

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